DOCUMENT RESUME

ED 118 461 SE 020 361

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TITLE Evolution in an Integrated Program.
PUB DATE Jun 75
NOTE 13p.; Paper presented at the Annual Meeting of the American Society for Engineering Education (Colorado State University, Ft. Collins, Colorado, June 16-19 1975); Occasional light print

EDRS PRICE MF-$0.83 HC-$1.67 Plus Postage
DESCRIPTORS College Science; Conference Reports; *Educational Programs; Engineering; *Engineering Education; *Higher Education; Management Education; *Program Descriptions; Science Education
IDENTIFIERS *Saudi Arabia

ABSTRACT

A description is given of a bifurctional, integrated Chemical Engineering program at the College of Petroleum and Minerals in Saudi Arabia. The Program and the institution have evolved from a highly technical and specialized orientation to one that can be characterized as a broader based, management orientation. A synthesis is given of the reasons for the evolution and the potential impact of the evolution on training foreign students in the United States. (MLH)

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ED118461

EVENT NO. 3520

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

ANNUAL CONFERENCE, JUNE 16-19, 1975

COLORADO STATE UNIVERSITY
FT. COLLINS, CO 80521

"EVOLUTION IN AN INTEGRATED PROGRAM"

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"EVOLUTION IN AN INTEGRATED PROGRAM"

SUMMARY:

The College of Petroleum and Minerals in Dhahran, Saudi Arabia operates a bifunctional, integrated Chemical Engineering program based on U.S. standards(1). The program and the institution have evolved from a highly technical and specialized orientation to one which can be characterized as a broader based, management orientation. Presented herein is the author's synthesis of the reasons for the evolution and the potential impact of the evolution on training foriegn students in the U.S.A.

The development of a quantitative management option within the traditional chemical engineering program is strongly recommended. A brief outline of such an option is presented.

INTRODUCTION:

The College of Petroleum and Minerals was established in 1964 as a semi-autonomus government institution to produce engineers in support of the petroleum and minerals industry. A detailed history of the development of the institution and relevant statistics have been published elsewhere(1,2). Basically it operated as a junior college until 1968 with students transferring to U.S. universities at the end of two years. In 1968, three Colleges were established: Science, Engineering Science and Applied Engineering. All students first entered a one-year Orientation or Prepartory program consisting of intensive instruction in English, Physics, Chemistry and Mathematics. After the Orientation year the students elect to enter one of the three Colleges. Initially the Engineering Science program was five (5) years or 160 semester hours in length while the Applied Engineering program was four years or 162

semester hours in length including a 12 semester hour work-study or coop year in local industry. The Science curriculum was four (4) years or 128 semester hours in length. All of the Orientation and College courses are taught in English, by American, British and French faculty. Most of the texts in the Science and Engineering Science programs are standard in U.S. engineering programs.

Following the U.S. pattern, the early programs had few electives, concentrated on the discipline areas and were comprehensive in both scope and depth. As the programs developed, they were shortened and electives were included. Many of the general studies electives were in Economics, Business and other management related areas. Table 1 contains a brief summary of the credit hour development of the Chemical Engineering Science program.

TABLE 1

CHEMICAL ENGINEERING SCIENCE PROGRAM

YEAR	SEMESTER CREDIT HOURS	TECHNICAL ELECTIVE HOURS	LENGTH (YRS)	COMMENTS
OCT/68	174	NONE	4	PROPOSED
NOV/68	227	NONE	5	PROPOSED
JAN/69	160	9	5	ADOPTED
NOV/69	160	9	5	PROPOSED, INCREASED CHEMISTRY
/69	160	13	5	ADOPTED
OCT/72	144	9	4	PROPOSED
JUNE/73	144	15	4	ADOPTED
SEPT/73	144	15	4	ADOPTED, DECREASED PHYSICS
JAN/75	144	12	4	PROPOSED

In 1964, the College had 50 students while 10 years later the enrollment stands at over 1500. There have been three graduating classes: 30 students in 1972, 65 in 1973 and 130 in 1974(1).

In 1973/4 an M.Sc. program was established with the first students enrolled in the Petroleum Engineering program. In 1974/5 a College of Industrial Management was established. This new College also offers electives to Engineering and Science students.

The importance of the College of Petroleum and Minerals in Saudi Arabia stems from several factors.

1. Arabia is one of the most rapdily developing countries in the world, particularly in the petroleum and petrochemical areas.
2. The College is the only institution in Arabia which offers a Chemical Engineering program.
3. Few Saudi students study Chemical Engineering abroad at the undergraduate level.

Even though Arabia in general and the College in particular are somewhat unique, the observations presented herein should be applicable to other less developed countries located in the Middle East (i.e. particularly those with major petroleum resources).

SUPPLY AND DEMAND:

Where a Saudi chemical engineer will work and what he will do depend on the supply and demand relationship for such resources. The demand for CH.E.s spans the entire gamut of applications from petroleum and petrochemical opertions to detergent plants, steel mills, dairy products operations, desalination plants, mineral extraction projects, municipal waste projects and agricultural

projects. Included in the above is one of the worlds largest urea plants (1500 tons/day). Industry as it exists in Arabia today (and other Middle Eastern countries) has been described in a recent issue of "ARAMCO WORLD MAGAZINE"[3]. Industrial development plans for Arabia have been reported in the first 5 year plan (1971-75) and in the newest 5 year plan (1976-1980)[4,5]. Excerpts from news releases of the new plan call for importation of 500,000 more foriegn workers in addition to the two (2) million foriegn workers already in Arabia[5]. The indigenous population of Arabia is somewhere between four (4) and six (6) million people.

Specific data on the demand for CH.E.'s is not readily available even in the published five year plan (1971-1975)[4]. There are a number of statistics, however, which are indicative of the magnitude of the demand. The statistics below were extracted from the five year plan (1971-75)[4]. In the private sector alone, for example, there were approximately 15,700 workers in the petroleum industry and an additional 13,700 in the mining and quarrying industry during 1970. The additional manpower requirement specified in the plan called for 770 managers and administrators plus 290 professional workers in the combined petroleum, mining and quarrying industries alone. For all industries, these requirements are for 3,935 additional managers and 2,445 additional professionals. All 2,445 of the professional workers and 260 of the managers must have university degrees. In one area of the public sector, PETROMIN (the Saudi Arabian Government holding company for petroleum and mineral ventures), the requirements for additional manpower were 70 managers and 450 professional workers. Note that in 1970, PETROMIN had 106 employees classified as Directors and managers and 122 classified as professional workers. In the entire public sector 8,799 additional

university graduates were required.

The demand for professional workers in both the public and private sector exceeded the supply by 4,600. For managers and administrators, the demand exceeded supply by 2,300. Past experience with planning efforts surely lead one to conclude that these estimates are certainly optimistic (i.e. the estimates above, in all probability, are low).

The current status, which should be contained in the new five year plan (1976-80), is not yet readily available. Personal communications, however, indicate that the projected growth rate for the next five years will exceed that of the last five years by a factor of two to five. Thus the demand will continue to outstrip the supply albeit at a higher rate.

The supply of chemical engineers, as presented below, obviates any need to identify the exact number of chemical engineers in the demand statistics above. Even the most conservative estimate would reveal a dramatic shortfall.

The primary supply of chemical engineers will be from the College of Petroleum and Minerals (CPM) with U.S. institutions as a secondary supply. The relevant secondary school data and the CPM data are summarized in Table 2. The data for CPM chemical engineers presented in Table 3 is even more revealing. In 1970, there were 1,740 Saudi students studying abroad (1,533 Bachelors, 137 Masters and 70 Doctoral). During the plan period (1970-75), 350 students were scheduled to graduate in Engineering, Architecture, etc.(4). Thus the supply of Chemical Engineering graduates is certainly less than 35 per year and probably less than 20. Of these graduates, a high percentage continue to pursue advanced degrees. The starting salaries for new graduates in government agencies are determined primarily by degree level, general area (i.e. M.S. in Engineering)

TABLE 2

STUDENT SUPPLY/CPM AND SECONDARY SCHOOLS(1)

	CPM			SECONDARY SCHOOLS		
YEAR	FACULTY	ADMISSIONS	TOTAL STUDENTS	TEACHERS	SCHOOLS	TOTAL STUDENTS(*)
1970	72	160	534	494	38	8,479
1971	95	246	720	627	45	11,566
1972	105	345	927	801	51	12,638
1973	132	456	1,236	938	55	14,170
1974	166	564	1,550	-	-	--
1978	-	-	-	-	-	47,000 Est.

(*) 25% Graduate Per Year/50% of Graduates In Science Curriculum/50% of Science Graduates Apply to CPM/ 50% of Applicants Accepted

TABLE 3

CHEMICAL ENGINEERS AT CPM

	ENGINEERING SCIENCE		APPLIED ENGINEERING	
YEAR	ENROLLED(+)	GRADUATES	ENROLLED(+)	GRADUATES
68/9	0	0	1	0
69/70	2	0	2	0
70/1	8	0	6	0
71/2	9	0	15	0
72/3	15	0	26	0
73/4	1	14	--	16
74/5	--	9		9
75/6	--	7	--	10
76/7	--	11	--	18

(+) By Year Of Enrollment Or Class

and position level. Little, if any, consideration is given to individual potential or past performance. Industry pay scales are pegged to meet government pay scales in order to avoid unfair competition. Thus the student is encouraged to

a) pursue graduate degrees and

b) apply for higher level positions (i.e. management and supervisory positions)

in order to maximize his income. Furthermore, a number of the Applied Engineering graduates have entered Engineering Science graduate programs. Thus the annual supply of B.S. graduates is even further diminished.

Since demand exceeds supply, foriegn engineers must be imported to make up the difference. What kind of foriegn engineers are imported is addressed in the next section.

MANAGERS OR TECHNICAL PERSONNEL?:

The policy regarding employment of foriegners to make up the demand-supply deficit can vary between two extremes:

a) managerial and supervisory positions should be filled with nationals whenever and wherever possible with foreigners assigned to technical tasks,

b) technical tasks should be assigned to nationals and managerial or supervisory positions assigned to foriegners with more experience.

Obviously there are any number of intermediate policies. The trend in general appears to be toward using nationals in managerial positions. This trend is particularly evident at CPM and in the Arabian American Oil Company (ARAMCO).

The trend has become more apparent at ARAMCO as the complete nationalization of ARAMCO proceeds. Presented below are a number of valid reasons in support of this policy.

In a recent article on engineering education in the Philippines[6], the authors put forth the concept that there is a specific need for programs that "adapt, innovate and diffuse technologies appropriate for local economic, social and cultural conditions." The indigenous manager with adequate technical background is more likely to succeed in the "appropriate", local implementation of technology. This is particulary evident when dealing with skilled and semi-skilled workers from Arabia and neighboring countries as well as when dealing with customs agents. The premise is that technology and quantitative management techniques are more transportable than cultural differences. All management objectives must be tempered by adequate consideration of such things as local customs, traditions and even holidays (e.g. in Arabia in particular and the Moslem world in general, employees fast during the day for an entire month each year and many also pray five times a day, every day). Foriegn management often over or under compensates for these and other similar factors. Thus a rather pragmatic case can be developed for employing indigenous managers with limited management experience and adequate technical qualifications.

A second factor in support of this policy relates directly to economics. It is obviously less expensive to import line technical personnel than management personnel. This is particularly true of "middle management" where careers may be interrupted to accept foriegn employment. Even though the Saudis have enormous, if not unlimited, fiscal resources, they are very prudent in fiscal matters.

The last, and somewhat weaker, factor in support of this policy relates directly to the magnitude of the demand - supply deficit. In the plan (1971-75), the deficit for managers and administrators is one half of the deficit for professional workers (i.e. 2,300 vs. 4,600). Thus there is a greater probability of diminishing the entire deficit in the management category by applying all available resources to the category with the smallest deficit. The net compensation is often lower for Saudis in the same positions as foriegners. Thus a policy which minimizes the occurrence of this inequity (and the resulting problems) is desirable.

Whether or not the reasons given above have any basis in fact, is somewhat irrelevant. Personal observation leads to the conclusion that the policy has been adopted and is being implemented with few exceptions. What impact does this policy have on present and future chemical engineering programs?

THE MANAGEMENT OPTION:

Program requirements must be sufficiently flexible to accommodate the training of foriegn students for early assignment to positions in technical management. This flexibility must not be developed at the expense of the basic technical foundations of the discipline.

As other special needs have developed in Chemical Engineering, the response has been to develop groupings of technical electives. At the University of Toledo, for example, a student has 18 quarter hours of technical electives and 7 quarter hours of free electives[7]. There are five (5) groupings of electives which include Environmental Engineering Pollution Control, Energy Conversion, etc. Thus an Engineering Management option could be an obvious extension of this concept.

The option should focus on quantitative techniques (e.g. accounting, project

management) and avoid qualitative material (personnel management, organizational administration, etc.). The qualitative material would be of minimal utility in a different cultural environment. A sample option is presented in Table 4. The courses recommended are based on similar courses taught in Operations Analysis by the College of Business Administration at the University of Toledo[7]. The importance of project management and quantitative analysis (e.g. linear programming) material cannot be over emphasized. Using an option or technical elective grouping to develop the necessary background in quantitative management techniques does not dilute the basic Chemical Engineering curriculum. "Instant experience" cannot be "packaged" but the tools for accelerating the learning process on the job can be acquired.

TABLE 4

ENGINEERING MANAGEMENT OPTION

PROJECT MANAGEMENT (CPM, PERT, etc.)
GENERAL ACCOUNTING
COST ACCOUNTING
CORPORATE FINANCE
QUANTITATIVE METHODS (linear programming, etc.)
BASIC CONTRACTS
SIMULATION METHODS (GPSS, etc.)

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